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ORIGINAL ARTICLE

Close relationship between the short round ligament and the ovarian prolapsed inguinal hernia in female infants

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Abstract

Purpose The aim of this study was to clarify the relationship between the length of the round ligament and the presence of a patent processus vaginalis (PV) based on the hypothesis that a short round ligament is the cause of ovarian inguinal hernia in female infants.

Methods Between April 2011 and March 2017, 132 girls underwent laparoscopic surgery for inguinal hernia. Before surgery, the presence of ovarian prolapse was diagnosed. We observed the internal inguinal ring laparoscopically and examined the diameter of the PV orifice as well as the round ligament length. Medical records and video records were reviewed to evaluate PV patency and round ligament length.

Results Seventeen of the 132 cases had an ovarian inguinal hernia; all of them were infants. In all infants, with or without a prolapsed ovary, the round ligament was short, causing the ovary and fallopian tube to be close to the hernia orifice over the pelvic brim. In girls aged over 12 months, the round ligament lengths on the hernia side, contralateral open PV side, and contralateral closed PV side were 33.0 ± 9.3, 36.8 ± 7.5, and 41.4 ± 8.5 mm, respectively. The round ligament length in open PV was significantly shorter than in the closed PV, but the difference was smaller in older patients.

Conclusion The round ligament, which is the female gubernaculum in the fetus, was shorter in the open PV than in the closed PV in younger girls. The short round ligament results in the ovarian prolapsed hernia.

Keywords Gubernaculum · Round ligament · Pediatric inguinal hernia · Laparoscopic percutaneous extraperitoneal closure

Introduction

Pediatric inguinal hernia is the most common disease treated by pediatric surgeons. In most cases, it is an indirect inguinal hernia due to failure of obliteration of a congenital peritoneal protrusion named the processus vaginalis (PV). In females, the ovary and/or fallopian tube is seen in the hernia sac as hernia contents and it typically occurs in 15–20% of female pediatric inguinal hernias [1].

In our institution, laparoscopic repair which was developed as laparoscopic percutaneous extraperitoneal closure (LPEC) by Takehara et al. [2] has been a standard surgical technique for pediatric inguinal hernia. This laparoscopic procedure enables us to observe the hernia orifice clearly. In girls with inguinal hernia, the hernia orifice and the round ligament are clearly observed. We sometimes observe a short round ligament during LPEC procedure in girls, which has caused the uterus horn to be close to the hernia orifice and as a result, the ovary and fallopian tube to be close to the hernia orifice. Based on the intraabdominal observation, Endo et al. [3] also showed that the ovary and fallopian tube are close to the hernia orifice over the pelvic brim in ovarian prolapsed hernia.

Our study aimed to uncover the relationships among ovarian inguinal hernia, the length of the round ligament, and PV patency.

Materials and methods

Between April 2011 and March 2017, 132 female patients of age ranging from 0 to 15 years underwent laparoscopic repair of inguinal hernia. Before each operation, the presence of ovarian prolapse was diagnosed by palpation and ultrasonographic examination.

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Surgical procedure

Patients were placed in the supine position, and general anesthesia was induced. A 5-mm trocar for the scope was inserted through the umbilicus, and 3-mm laparoscopic dissecting forceps (J1019, Storz, Tuttingen, Germany) were inserted in the right lateral abdomen. After careful inspection of the pelvic floor on both sides, we measured the diameter of the PV orifice and the length of the round ligament, and an LPEC needle (Lapaherclosure®; Hakko Medical Co., Nagano, Japan) holding a doubled 3-0 non-absorbable suture was introduced into the inguinal region just above the internal inguinal ring. The orifice of the hernia sac was closed with extraperitoneal circuit suturing around the internal inguinal ring using the LPEC needle.

Measurement of the round ligament and PV orifice

The diameter of the PV orifice on both the hernia side and the contralateral side and the lengths of the bilateral round ligaments were measured intraoperatively in 132 cases (264 sides). Each measurement during the operation was estimated based on the open width (15 mm) and the diameter (3 mm) of the forceps (Fig. 1). The diameter of the PV orifice was measured at the level of the internal inguinal ring. An open PV orifice was defined as having a diameter greater than or equal to 3 mm, while a closed PV was defined as one having a diameter less than 3 mm. We classified the internal inguinal ring into three types: "Type H" with clinically diagnosed hernia, "Type O" with open PV but clinically undiagnosed hernia and "Type C" with closed PV. The length of the round ligament was measured from the internal inguinal ring to the attachment of the uterine horn (Fig. 2). The round ligament length was recorded in 5-mm intervals.

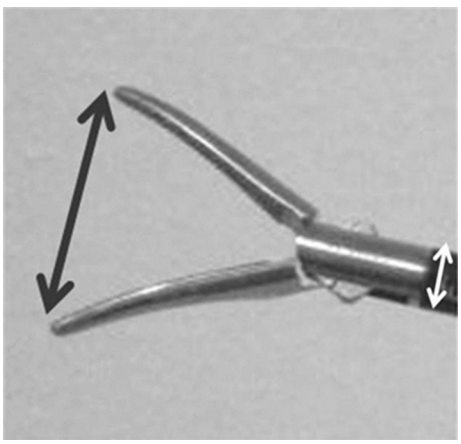

Fig. 1 The measurement using 3-mm forceps. Black arrow: open width 15 mm; white arrow; the diameter of the forceps (3 mm)

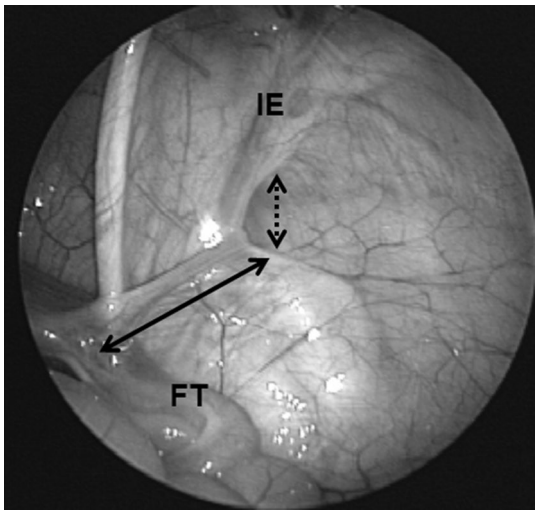

Fig. 2 The appearance around the right internal inguinal ring in a girl. Black dotted line: the vertical diameter of the PV orifice; black arrow: the length of the round ligament; *IE* inferior epigastric vessels, *Fa* fallopian tube

Data analysis

Medical records and video records were reviewed and analyzed. At first, to clarify the relationship between growth and round ligament length with normal internal inguinal ring, we analyzed the correlation between age and body height and the corresponding round ligament length in type C. Then, the round ligament length was compared among the groups of Type H, O and C, respectively, in ovarian prolapsed hernia and in non-ovarian prolapsed hernia. Finally, we conducted a scatter plot study of the round ligament length and body height in the groups of Type H + O and Type C.

All results are expressed as average values ± standard deviation (SD). Statistical analysis was conducted using statistical software (SPSS ver. 25.0; SPSS INC., Chicago, IL, USA). A non-parametric test was adopted for comparisons. $P < 0.05$ was considered significant.

Results

Statistics

The median age of the 132 patients was 4 years ranging from 1 month to 15 years. The number of patients with bilateral inguinal hernia was 14 and with unilateral inguinal hernia was 118. The number of Type H was 146 including 28 bilateral sides. The number of Type O was 56 and of Type C was 62.

Relationships between growth and round ligament length

To clarify how the round ligament length change by their growth, 62 children with type C which is regarded as the normal side were evaluated for the correlation between their age and body height and round ligament length. Each Spearman's rank correlation coefficient is 0.585 with age and 0.607 with body height; thus, the round ligament length was getting longer as age and body height.

Round ligament length in infants

Of 132 patients, 17 (12.9%) had ovarian hernias and they could be confirmed by ultrasonographic examination in outpatient clinic. Although seven cases were irreducible hernia, there was no strangulated ovary and no emergency surgery. Their age ranged from 30 days to 11 months. No ovarian prolapsed hernia was observed over the age of 12 months. The number of infantile inguinal hernia under 1 year of age was 20 and 17 cases (85%) had prolapsed ovary. The ratio of their inguinal ring type was as follows: Type H: 22 (55%); Type O: 5 (12.5%); and Type C: 13 (32.5%). The average round ligament length was 10.5 ± 6.7 mm in Type H, 20.0 ± 8.9 mm in Type O and 31.9 ± 6.4 mm in Type C. The round ligament with type H was significantly shorter than that with type C ($P < 0.001$). The round ligament with type O was not significantly different from that with type H ($P = 0.053$), but was significantly shorter than with type C ($P = 0.038$) (Table 1). There was no difference in age and body height among the three types.

Table 1 The length of the round ligament in infant (20 cases, 40 sides)

	Type H	Type O	Type C	*P*
n	22	5	13	
Age (month)	3.6 ± 3.4	1.6 ± 1.0	4.6 ± 4.0	NS
Height (cm)	57.8 ± 6.1	54.7 ± 1.7	60.1 ± 7.0	NS
Length of the round ligament (mm)	10.5 ± 6.7	20.0 ± 8.9*	31.9 ± 6.4**	< 0.05

*$P = 0.053$ versus Type H, **$P < 0.05$ versus Type O by Mann–Whitney's *U* test

In all ovarian hernia cases, the ovary and the fallopian tube were close to the hernia orifice over the pelvic brim (Fig. 3a). The short round ligament looked as though it was pulling these organs towards the internal hernia ring. There were no visible structures such as infundibulopelvic ligament in the hernia sac except for the round ligament and no findings of the round ligament retracting into the hernia sac. In addition, the length of the round ligament showed no change when it was pulled cranially by forceps. Only four sides showed non-ovarian hernia and the average of their round ligament length was as short as 15 mm (range 0–25). As a result, the ovary and fallopian tube were close to the hernia orifice over the pelvic brim (Fig. 3b).

The round ligament length aged over 12 months

Of 112 cases (224 sides) of age over 12 months, the number of Type H was 124, Type O was 51 and Type C was 49. The average length of the round ligament was 33.0 ± 9.3 in Type H, 36.8 ± 7.5 in Type O and 41.4 ± 8.5 in Type C (Table 2). In the comparison of the round ligament length in each type, the length in Type H was significantly shorter than that in Type O ($P = 0.009$) and the length in Type O was also significantly shorter than that in Type C ($P = 0.006$). There was no difference in age and body height among the three types.

The round ligament length and body height in Type H+O and Type C

Figure 4 shows a scatter plot of the round ligament length and body height in Type H + O and Type C. The short round ligament length in Type H + Type O exhibited lengthening as body height increased. The lengths in both groups were similar in cases with a body height more than 130 cm, which were 41.3 ± 6.8 mm in Type H + O and 46.9 ± 10.3 mm in Type C ($P = 0.15$).

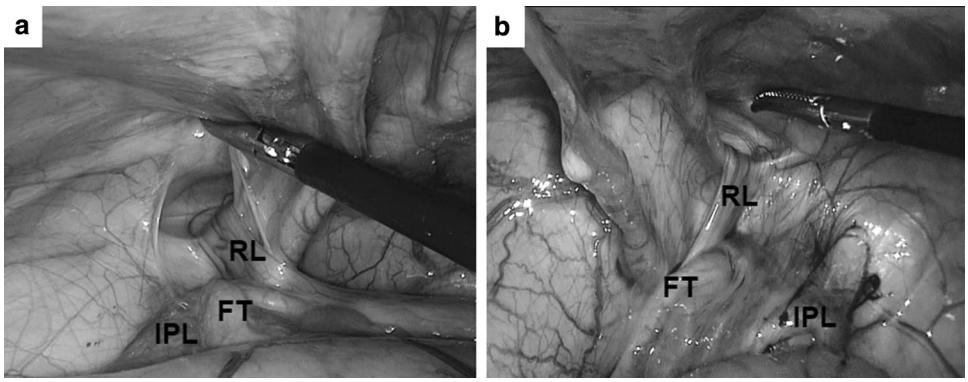

Fig. 3 **a** Ovary prolapsed hernia. **b** Intestinal prolapsed hernia. *RL* round ligament, *FT* fallopian tube, *IPL* infundibulopelvic ligament

Table 2 The length of the round ligament in girls aged over 12 months (112 cases, 224 sides)

	Type H	Type O	Type C	*P*
n	124	51	49	
Age (year)	5.3 ± 2.8	5.0 ± 2.8	5.8 ± 3.0	NS
Height (cm)	107.8 ± 19.2	105.7 ± 19.1	110.6 ± 19.8	NS
Length of the round ligament (mm)	33.0 ± 9.3	36.8 ± 7.5*	41.4 ± 8.5**	< 0.05

*$P < 0.5$ versus Type H, **$P < 0.5$ versus Type O by Mann–Whitney's *U* test

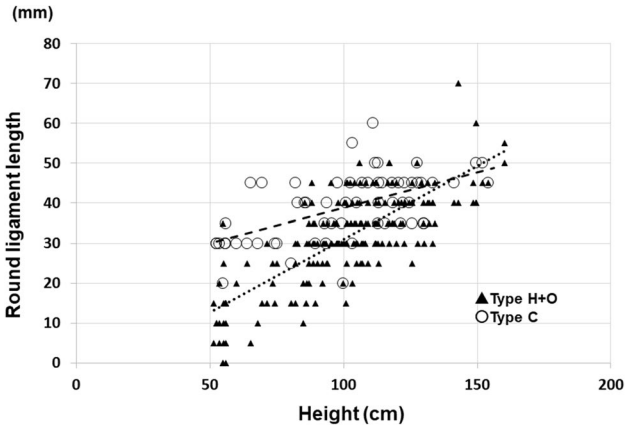

Fig. 4 A scatter plot of body height and round ligament length in type H + O and type C

Discussion

A prolapsed ovary into a hernial sac is typically seen in 15–20% of female pediatric inguinal hernias [1]. Takehara et al. [4] reported that 46 cases of pediatric ovarian prolapsed inguinal hernia were observed in patients less than 4 years old and that 69.6% of cases were under 4 months of age. In other reports, 70% of sliding inguinal hernia, in which the most common sliding organ is the ovary followed by the fallopian tube, was seen in infants younger than 1 year [5], and the incidence decreases with age [6]. Similarly, our data showed that 85% of infants with hernia had prolapsed ovary, while patients aged over 1 year had no prolapsed ovaries.

Ozbey et al. [7] suggested that the ovary in the hernia sac may not simply be prolapsed, but is a descended gonad, based on their research that there were sex hormone receptors on the ligaments in the hernia sac. In contrast, Hutson and Kearsey [8] mentioned that ovarian hernia was not ovarian 'descent', but rather pulled by the ovarian attachments (cranial suspending ligament, etc.) and the ovary into a pulsion diverticulum by sliding the adjacent parietal peritoneum into the hernia sac. Therefore, they proposed that the short round ligament is likely to be a result of sliding the peritoneum into the inguinal canal.

However, our data showed that the short round ligament was found not only in ovarian prolapsed inguinal hernia, but also in non-ovarian prolapsed inguinal hernia and even in non-hernia but with open PV, such as Type O. If the short round ligament was a result of sliding the peritoneum into the inguinal canal, the length should be short in older patients. In fact, the round ligament was getting longer according to their growth, and as a result, the ovary was not prolapsed in older children above 1 year old.

It may be said of our research that we measured only the intraperitoneal part of the round ligament and not the caudal part below the internal ring. However, we think that the short round ligament is related to the occurrence of ovary prolapsed inguinal hernia, because there were no intraoperative findings that the round ligament had been pulled into the hernia sac along with a sliding peritoneum.

The round ligament is thought to be the female gubernaculum in fetuses, with the homologous structure of the male gubernaculum [9]. In boys, testicular descent occurs under the control of the male gubernaculum during fetal development. In contrast, the female gubernaculum, which is called the round ligament after birth, normally holds the ovaries in the peritoneal cavity. Compared to the male gubernaculum, little attention has been paid to the function of the female gubernaculum.

The gubernaculum, described by Hunter in 1762, has been considered to be an embryonic structure connected from the internal genitalia to the inguinal abdominal wall, and its function is related to testicular descent [10]. The anatomy and development of the gubernaculum are still equivocal. Most embryology books described that the peritoneal fold covering the gonadal ridge and the mesonephros forms the cranial gonadal suspensory ligament (CSL) on the cranial side and the gubernaculum on the caudal side [11, 12]. While the male gubernaculum is responsible for testicular descent, the female gubernaculum is divided into two parts by the Müllerian duct; the cranial part becomes the proper ligament of the ovary, and the caudal part becomes the round ligament [11].

However, there is another view of the gubernaculum. Schoot et al. [13] have shown histological sections through the inguinal region of the female human fetus in which the structure emerged from the inguinal abdominal wall connected to the Müllerian duct; therefore, they suggested that this structure is the gubernaculum and is derived from the abdominal wall.

Acien et al. [9] agreed with Schoot's [13] view. They showed a difference in the muscular fiber arrangement between the uterine horn (the gubernaculum attachment site) and the uterine fundus, thus suggesting that the

gubernaculum from the abdominal wall connects to the Müllerian duct and leads the Müllerian duct into the normal uterus. They also reported that Müllerian duct abnormalities such as Rokitansky syndrome and uterus didelphys are associated with pathologies of the round ligament and inguinal hernia. Thus, they suggest that the female gubernaculum is responsible for the normal development of the female internal genitalia.

We infer, based on the past studies above and our data, the female gubernaculum leads to the development of the female internal genital organs, which is involved in the position of the ovaries and PV obliteration. Though further studies are needed, it appears that the insufficient development of the gubernaculum may result in a short round ligament and the failure of obliteration of the PV, causing prolapsed ovary rather than "gonadal descent".

In conclusion, the round ligament was shorter in ovarian prolapsed hernia in infants and getting longer as according to their growth. We believe that the ovarian prolapsed hernia results from the short round ligament.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of Kawasaki Medical School and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Approval for this study was obtained from the Research Ethics Committee of Kawasaki Medical School and Hospital (no. 2959). For this type of study, formal individual consent was not required.

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